78
INTRODUCTION TO AMPHIBIANS AND REPTILES

The class Amphibia includes approximately three thousand species arranged into three orders of living representatives: the toads and frogs (order Anura), the salamanders and newts (order Caudata), and the limbless caecilians (order Apoda, not shown). Amphibians are especially significant, as they represent the most primitive vertebrates with four limbs maintaining a basically terrestrial niche. The kinds of structural adaptations required to survive in a nonaquatic environment have been significant, especially with regards to development of jointed limbs and respiration by lungs. However, the thin, glandular skin of amphibians generally requires that they find habitats near fresh water (salt water is lethal).

The seven thousand or more species of the class Reptilia have been more successful in creating a nonaquatic, terrestrial niche. Their thick, scaly skin resists water loss and their lungs have much more surface area for gas exchange; so they no longer require skin as a respiratory surface. The living representatives of the class include the lizards and snakes (order Squamata), the alligators and crocodiles (order Crocodilia), and the turtles and tortoises (order Chelonia).

Color the representatives of the class Amphibia and read below.

Frogs are found in temperate and tropical climates around the world. They are largely insectivorous and generally live close to the water. The detailed systemic structure of the North American bullfrog *(Rana catesbeiana)* can be colored in Plates 79 through 87.

Toads, sharing the same order with *frogs* and found in similar regions of the world, are generally characterized by their wart-covered skin. Skin glands of *toads* (and some *frogs*) secrete a poison that repels predators. *Salamanders* and newts, usually about 10 to 15 centimeters long, are tailed amphibians with largely cartilaginous limbs. Like *toads* and *frogs,* they have poison glands and live near water, under moist rocks and logs. The *salamanders* include the giant salamander, American hell bender, which is over 60 centimeters long, and the mud puppy *(Necturus),* which is commonly dissected in comparative anatomy classes.

Color the representatives of the class Reptilia and read below.

Lizards (three thousand species) are herbivorous or carnivorous animals found in tropical and temperate climates around the world. *Lizards* (the collared lizard is shown here) are characterized by slender, scaly-skinned bodies with four limbs (although some are legless) and a length of 25 centimeters or longer. Many *lizards* have special features in their caudal vertebrae that make them capable of autotomy (breaking off a part of their tail).

The *turtles,* which may be herbivorous or carnivorous, include some two hundred species of terrestrial and lung-breathing aquatic animals found around the world. Marine turtles are often quite large and may weigh well over 2,000 kilograms. The plates or shell of the *turtle* consist of ribs and dermal bone covered with scales.

The *snakes* (about three thousand species of carnivorous serpents) lack limbs, a sternum or breastplate, external ear openings, and a urinary bladder. Many adult *snakes* exhibit hundreds of vertebrae and ribs along the length of their serpentine bodies. The jaws of many snakes are unique in being able to open widely, permitting swallowing of large prey (including rabbits and even deer). Such a characteristic is made possible by the quadrate bone having a loose attachment to both upper and lower jaws. *Snakes* may reach lengths of 8 meters or more.

The *alligators* and crocodiles are the largest four-limbed reptiles and are organized into about twenty species. They are characterized by very powerful jaws with blunt conical teeth, a heavy tail, and thick, heavily scaled skin. They exist in tropical and subtropical climates around the world.

The embryos of reptiles are the most primitive vertebrates to develop within a thin sac filled with fluid (amnion/amniotic fluid). Such embryos do not leave the amnion until just before birth. Vertebrates having an amnion during embryonic development, including birds and mammals as well as reptiles, are termed amniotes, as opposed to anamniotes.

Background Information

Taxonmony
Kingdom-Animalia
Phylum -Chordata
Class-Amphibia
Order-Salientia
Family-Ranidae
Genus-*Rana*
Species-*pipiens, utricularia, blair, berlandieri, palustris*

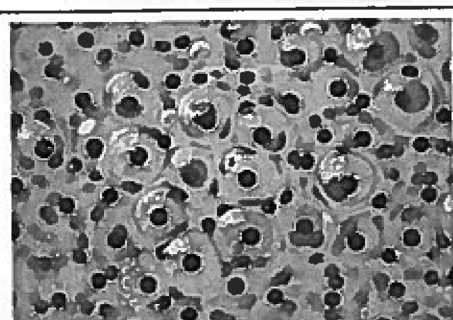
The leopard frog has been surrounded by much controversy over whether there is actually only one species, or if the species can be separated into more than species. Primarily their outer skin markings, and also the region from which they are found tell the leopard frogs apart. The species that the leopard frog has been separated into are: Rana pipiens (Northern Leopard Frog), Rana utricularia (Southern Leopard Frog), Rana blairi (Plains Leopard Frog), Rana berlandieri (Rio Grande Leopard Frog), and Rana palustris (Pickerel Frog)..

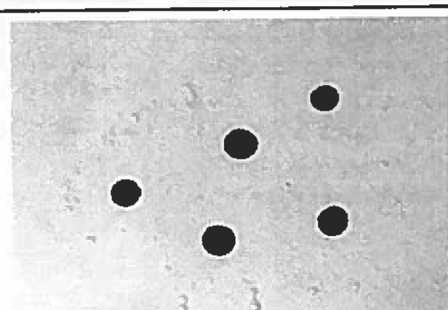
A frog is a fresh-water amphibian of the family Ranidae. They are closely related to toads. The Ranidae are sometimes called the "true frogs" since a few members of other families also have common names including the word "frog." Due to their permeable skin, frogs are often semi-aquatic or inhabit humid areas, but move easily on land. Frogs are most noticeable by their call, which can be widely heard during the night or day, mainly in their mating season. The distribution of frogs ranges from tropic to subarctic regions, but most species are found in tropical rainforests. Consisting of more than 5,000 species described, they are among the most diverse groups of vertebrates. However, populations of certain frog species are declining significantly.

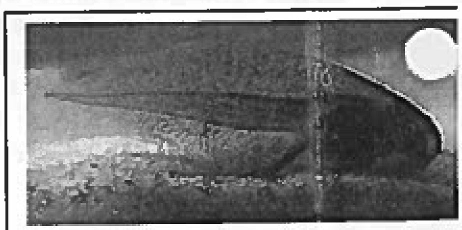
A distinction is often made between frogs and toads on the basis of their appearance, caused by the **convergent adaptation** among so-called toads to dry environments.

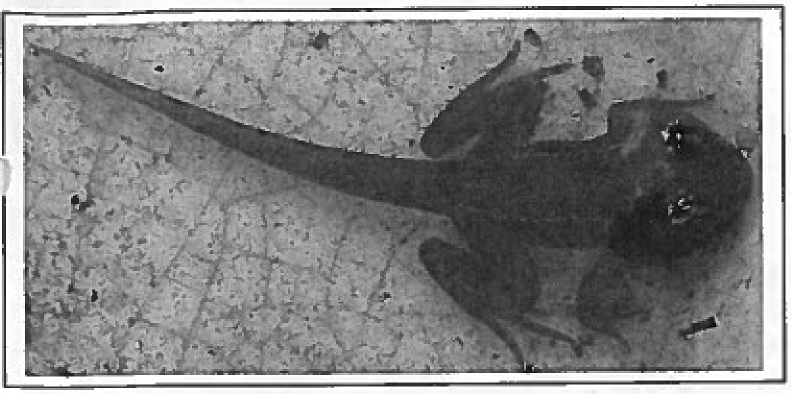
Frogs require a moist habitat. They prefer streams, springs, ponds, and lakes. They would like the water to be clear and clean in an open area or at least in a lightly wooded area. Normally they can travel inland at least ½ km, but if it has been a wet season then they can travel much further. (Heinen 1997)
It is hard to find a leopard frog during the day. They are usually resting in wet areas that are shallow. This helps them to be more protected from predators. The basking in the sun helps them to raise their temperature, which in turn helped them to digest their food. As soon as dusk sets in, they will move from their place of hiding to hunt. In winter the frogs are very inactive and can be found resting on the bottom of a lake, or under stones in springs, streams, or rivers. Where there is an adequate amount of oxygen Heinen

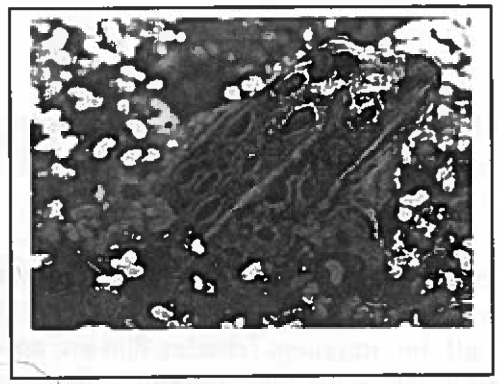
Life Cycle
In many parts of the world the frog population has declined drastically over the last few decades. Pollutants are one cause for this decline but other culprits include climatic changes, parasitic infestation, introduction of non-indigenous predators/competitors, infectious diseases, and urban encroachment.











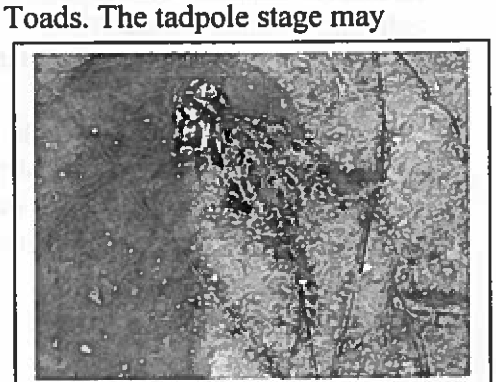
The life cycle of a frog starts with an egg. A female generally lays gelatinous egg masses containing thousands of eggs, in water. Each anuran species lays eggs in a distinctive, identifiable manner. The eggs are highly vulnerable to predation, so frogs have **evolved** many techniques to ensure the survival of the next generation. In colder areas the embryo is black to absorb more heat from the sun, which speeds up the development. Many individuals will breed at the same time, overwhelming the actions of predators; the majority of the offspring will still die due to predation, but there is a greater chance some will survive.

Another way in which some species avoid the predators and pathogens eggs are exposed to in ponds is to lay eggs on leaves above the pond, with a gelatinous coating designed to retain moisture. In these species the tadpoles drop into the water upon hatching. The eggs of some species laid out of water can detect vibrations of nearby predatory wasps or snakes, and will hatch early to avoid being eaten. Some species, such as the Cane Toad (*Bufo marinus*), lay poisonous eggs to minimize predation. While the length of the egg stage depends on the species and environmental conditions, aquatic eggs generally hatch within one week. Other species go through their whole larval phase inside the eggs or the mother, or they have direct development. Unlike salamanders and newts, frogs and toads never become sexually mature while still in their larval stage.

Eggs hatch and continue life as tadpoles (occasionally known as polliwogs), which typically have oval bodies and long, vertically flattened tails. They lack lungs, eyelids, front and hind legs, and have a cartilaginous skeleton, a lateral line system, gills for respiration (external gills at first, internal gills later) and tails with dorsal and ventral folds of skin for swimming.[1] Some species which go through the metamorphosis inside the egg and hatch to small frogs never develop gills, instead there are specialized areas of skin that takes care of the respiration. Tadpoles also lack true teeth, but the jaws in most species usually have two elongate, parallel rows of small keratinized structures called keradonts in the upper jaw while the lower jaw has three rows of keradonts, surrounded by a horny beak, but the number of rows can be lower or absent, or much higher.

Tadpoles are typically herbivorous, feeding mostly on algae, including diatoms filtered from the water through the gills. Some species are carnivorous at the tadpole stage, eating insects, smaller tadpoles, and fish. Cannibalism has been observed among tadpoles. Early developers who gain legs may be eaten by the others, so the late bloomers survive longer. This has been observed in England in the species *Rana temporaria* (common frog).[32]

Tadpoles are highly vulnerable to predation by fish, newts, predatory diving beetles and birds such as kingfishers. Poisonous tadpoles are present in many species, such as Cane Toads. The tadpole stage may be as short as a week, or tadpoles may overwinter and metamorphose the following year in some species, such as the midwife toad and the common spadefoot



Reproduction of frogs

Once adult frogs reach maturity, they will assemble at a water source such as a pond or stream to breed. Many frogs return to the bodies of water where they were born, often resulting in annual migrations involving thousands of frogs. In continental Europe, a large proportion of migrating frogs used to die on roads, before special fences and tunnels were built for them.

Once at the breeding ground, male frogs call to attract a mate, collectively becoming a chorus of frogs. The call is unique to the species, and will attract females of that species. Some species have satellite males who do not call, but intercept females that are approaching a calling male.
Reproduction involves the male mounting the female and gripping her (sometimes with special nuptial pads) tightly. Fertilization is external: the egg and sperm meet outside of the body. The female releases her eggs, which the male frog covers with a sperm solution. The eggs then swell and develop a protective coating. The eggs are typically brown or black, with a clear, gelatin-like covering.
Most temperate species of frogs reproduce between late autumn and early spring. In the UK, most common frog populations produce frogspawn in February, although there is wide variation in timing. Water temperatures at this time of year are relatively low, typically between four and 10 degrees Celsius, (50 degrees Fahrenheit). Reproducing in these conditions helps the developing tadpoles because dissolved oxygen concentrations in the water are highest at cold temperatures. More importantly, reproducing early in the season ensures that appropriate food is available to the developing frogs at the right time.

Parental care

Although care of offspring is poorly understood in frogs, it is estimated that up to 20% of amphibian species may care for their young in one way or another, and there is a great diversity of parental behaviors. Some species of poison dart frog lay eggs on the forest floor and protect them, guarding the eggs from predation and keeping them moist. The frog will urinate on them if they become too dry. After hatching, a parent (the sex depends upon the species) will move them, on its back, to a water-holding bromeliad. The parent then feeds them by laying unfertilized eggs in the bromeliad, (type of tropical flower) until the young have metamorphosed. Other frogs carry the eggs and tadpoles on their hind legs or back. Some frogs even protect their offspring inside their own bodies. The male Australian Pouched Frog has pouches along its side in which the tadpoles reside until metamorphosis. The female Gastric-brooding Frogs from Australia, now probably extinct, swallows its tadpoles, which then develop in the stomach. To do this, the Gastric-brooding a frog must stop secreting stomach acid and suppress peristalsis (contractions of the stomach). Darwin's Frog from Chile puts the tadpoles in its vocal sac for development. Some species of frog will leave a 'babysitter' to watch over the frogspawn until it hatches.

Call

Some frog calls are so loud, they can be heard up to a mile away. The call of a frog is unique to its species. Frogs call by passing air through the larynx in the throat. In most calling frogs, the sound is amplified by one or more vocal sacs, membranes of skin under the throat or on the corner of the mouth that distend during the amplification of the call.

Some frogs lack vocal sacs, such as those from the genera *Heleioporus* and *Neobatrachus*, but these species can still produce a loud call. Their buccal cavity is enlarged and dome-shaped, acting as a resonance chamber that amplifies their call. Species of frog without vocal sacs and that do not have a loud call tend to inhabit areas close to flowing water. The noise of flowing water overpowers any call, so they must communicate by other means.

The main reason for calling is to allow males to attract a mate. Males call either individually or in a group called a chorus. Females of many frog species, for example *Polypedates leucomystax*, produce calls reciprocal to the males', which act as the catalyst for the enhancement of reproductive activity in a breeding colony. Tropical species also have a rain call that they make on the basis of humidity cues prior to a rain shower. Many species also have a territorial call that is used to chase away other males. All of these calls are emitted with the mouth of the frog closed.

Diet

Frogs eat insects such as mosquitoes and small animals such as minnows. Their sticky tongues are effective in catching fast-moving preys. They hunt mostly at night. Adult frogs follow a carnivorous diet, mostly of arthropods, (insects) annelids, (worms) and gastropods, (slugs).

Frogs are a diverse group with some 5,000 species. Most spend their lives in or near a source of water (water frogs), although tree frogs live in moist environments that are not actually aquatic. The requirement for water becomes most acute for egg and tadpole stages of the frog, yet here again some species are able to utilize temporary pools and water collected in the axils of plants.

The most familiar frogs are the Bullfrog, the Edible frog, the Leopard frogs, Spring Peepers, and the Green Frogs. Many species of frog secrete toxins from their skin when under threat. These toxins deter predatory animals from eating them, and some are extremely poisonous to humans. The natives of the Amazon area extract curare from the poison arrow frog.

Physiology/Body Shape

Frogs have three eyelid membranes: one is transparent to protect the eyes underwater, and two vary from translucent to opaque. Frogs have a tympanum on each side of the head, which is involved in hearing and, in some species, is covered by skin. Most frogs have teeth, but only have teeth on the edge of the upper jaw (*maxillary teeth*) as well as *vomerine teeth* on the roof of their mouth. They do not have any teeth on their lower jaw, so they usually swallow their food whole. The teeth are mainly used to hold the prey and keep it in place till they can get a good grip on it and swallow their meal, assisted by retracting their eyes into their head. True toads lack any teeth at all, and some species (Pyxicephalus) which prey on relatively large organisms (including mice and other frogs) have cone shaped projections of bone, called odontoid processes, at the front of the lower jaw which function like teeth.

Feet and legs

The structure of the feet and legs varies greatly among frog species, depending in part on whether they live primarily on the ground, in water, in trees, or in burrows. Frogs must be able to move quickly through their environment to catch prey and escape predators, and numerous adaptations help them do so. Many frogs, especially those that live in water, have webbed toes. The degree to which the toes are webbed is directly proportional to the amount of time the species lives in the water. For example, the completely aquatic African dwarf frog has fully webbed toes, whereas the toes of White's tree frog, an arboreal, (tree) species, are only a half or a quarter webbed.

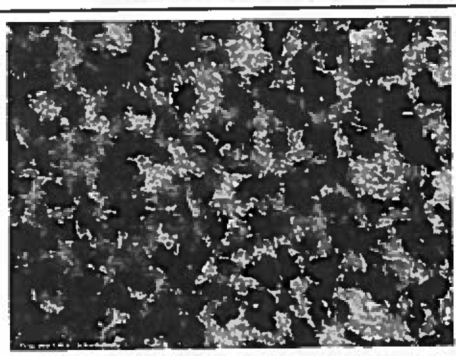
Arboreal frogs have "toe pads" to help grip vertical surfaces. These pads, located on the ends of the toes, do not work by suction. Rather, the surface of the pad consists of interlocking cells, with a small gap between adjacent cells. When the frog applies pressure to the toe pads, the interlocking cells grip irregularities on the substrate. The small gaps between the cells drain away all but a thin layer of moisture on the pad, and maintain a grip through capillarity. This allows the frog to grip smooth surfaces, and does not function when the pads are excessively wet.

Since hopping through trees can be dangerous, many arboreal frogs have hip joints that allow both hopping and walking. Some frogs that live high in trees even possess an elaborate degree of webbing between their toes, as do aquatic frogs. In these arboreal frogs, the webs allow the frogs to "parachute" or control their glide from one position in the canopy to another.

Ground-dwelling frogs generally lack the adaptations of aquatic and arboreal frogs. Most have smaller toe pads, if any, and little webbing. Some burrowing frogs have a toe extension—a metatarsal tubercle—that helps them to burrow. The hind legs of ground dwellers are more muscular than those of aqueous and tree-dwelling frogs.

Frogs are generally recognized as exceptional jumpers, and the best jumper of all vertebrates. The Australian rocket frog, can leap over 50 times its body length (5.5 cm), resulting in jumps of over 2 meters. The acceleration of the jump may be up to twice gravity. There are tremendous differences between species in jumping capability, but within a species, jump distance increases with increasing size, but relative jumping distance (body-lengths jumped) decreases.

While frog species can use a variety of locomotor modes (running, walking, gliding, swimming, and climbing), more are either proficient at jumping or descended from ancestors who were, with much of the musculo-skeletal morphology modified for this purpose. The tibia, fibula and tarsals have been fused into a single, strong bone, as have the radius and ulna in the forelimbs (which must absorb the impact of landing). The metatarsals have become elongated to add to the leg length and allow the frog to push against the ground for longer during a jump. The illium has elongated and formed a mobile joint with the sacrum which, in specialist jumpers such as Ranids or Hylids, functions as an additional limb joint to further power the leaps. This elongation of the limbs results in the frog being able to apply force to the ground for longer during a jump, which in turn results in a longer, faster jump.



Skin (Microscopic view of frog skin)

Many frogs are able to absorb water and oxygen directly through the skin, especially around the pelvic area. However, the permeability of a frog's skin can also result in water loss. Some tree frogs reduce water loss with a waterproof layer of skin. Others have adapted behaviors to conserve water, including engaging in nocturnal activity and resting in a water-conserving position. This position involves the frog lying with its toes and fingers tucked under its body and chin, respectively, with no gap between the body and substrate. Some frog species will also rest in large groups, touching the skin of the neighboring frog. This reduces the amount of skin exposed to the air or a dry surface, and thus reduces water loss. These adaptations only reduce water loss enough for a predominantly arboreal existence, and are not suitable for arid conditions.

Camouflage is a common defensive mechanism in frogs. Most camouflaged frogs are nocturnal, which adds to their ability to hide. Nocturnal frogs usually find the ideal camouflaged position during the day to sleep. Some frogs have the ability to change color, but this is usually restricted to shades of one or two colors. For example, White's tree frog varies in shades of green and brown. Features such as warts and skin folds are usually found on ground-dwelling frogs, where a smooth skin would not disguise them effectively. Arboreal frogs usually have smooth skin, enabling them to disguise themselves as leaves.

Certain frogs change color between night and day, as light and moisture stimulate the pigment cells and cause them to expand or contract.

Many frogs contain mild toxins that make them unpalatable to potential predators. For example, all toads have large poison glands—the parotid glands—located behind the eyes, on the top of the head. Some frogs, such as some poison dart frogs, are especially toxic. The chemical makeup of toxins in frogs varies from irritants to hallucinogens, consultants, nerve poisons, and vasoconstrictors. Many predators of frogs have adapted to tolerate high levels of these poisons. Others, including humans, may be severely affected. Some frogs obtain poisons from the ants and other arthropods they eat;

Respiration and circulation

The skin of a frog is permeable to oxygen and carbon dioxide, as well as to water. There are a number of blood vessels near the surface of the skin. When a frog is underwater, oxygen is transmitted through the skin directly into the bloodstream. On land, adult frogs use their lungs to breathe. Their lungs are similar to those of humans, but the chest muscles are not involved in respiration, and there are no ribs or diaphragm to support breathing. Frogs breathe by taking air in through the nostrils (which often have valves which close when the frog is submerged), causing the throat to puff out, then compressing the floor of the mouth, which forces the air into the lungs. In August 2007 an aquatic frog named *Barbourula kalimantanensis* was discovered in a remote part of Indonesia. The Bornean Flat-headed Frog (*B. kalimantanensis*) is the first species of frog known to science without lungs.

Frogs are known for their three-chambered heart, which is unlike except birds, and mammals. In the three-chambered heart, oxygenated blood from the lungs and de-oxygenated blood from the respiring tissues enter by separate atria, and are directed via a spiral valve to the appropriate vessel—aorta for oxygenated blood and pulmonary artery for deoxygenated blood. This special structure is essential to keeping the mixing of the two types of blood to a minimum, which enables frogs to have higher metabolic rates, and to be more active than otherwise.

Some species of frog have remarkable adaptations that allow them to survive in oxygen deficient water. The lake titicaca frog (*Telmatobius culeus*) is one such species and to survive in the poorly oxygenated waters of Lake Titicaca it has incredibly wrinkly skin that increases its surface area to enhance gas exchange. This frog will also do 'push-ups' on the lake bed to increase the flow of water around its body.

Digestion and excretion

The frog's digestive system begins with the mouth. Frogs have teeth along their upper jaw called the maxillary teeth, which are used to grind food before swallowing. These teeth are very weak, and cannot be used to catch or harm agile prey. Instead, the frog uses its sticky tongue to catch food (such as flies or other insects). The food then moves through the esophagus into the stomach. The food then proceeds to the small intestine (duodenum and ileum) where most digestion occurs. Frogs carry pancreatic juice from the pancreas, and bile (produced by the liver) through the gallbladder from the liver to the small intestine, where the fluids digest the food and extract the nutrients. When the food passes into the large intestine, the water is reabsorbed and wastes are routed to the cloaca. All wastes exit the body through the cloaca and the cloacal vent.

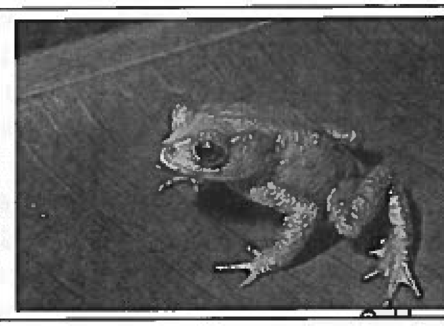
Nervous system

The frog has a highly developed nervous system which consists of a brain, spinal cord and nerves. Many parts of the frog's brain correspond with those of humans. The medulla oblongata regulates respiration, digestion, and other automatic functions. Muscular coordination and posture are controlled by the cerebellum. The relative size of the cerebrum of a frog is much smaller than that of a human. Frogs have ten cranial nerves (nerves which pass information from the outside directly to the brain) and ten pairs of spinal nerves (nerves which pass information from extremities to the brain through the spinal cord). By contrast, all amniotes (mammals, birds and reptiles) have twelve cranial nerves. Frogs do not have external ears; the eardrums (tympanic membranes) are directly exposed. As in all animals, the ear contains semicircular canals which help control balance and orientation.

Natural history

The life cycle of frogs, like that of other amphibians, consists of four main stages: *egg, tadpole, metamorphosis and adult*. The reliance of frogs on an aquatic environment for the egg and tadpole stages gives rise to a variety of breeding behaviors that include the well-known mating calls used by the males of most species to attract females to the bodies of water that they have chosen for breeding. Some frogs also look after their eggs—and in some cases even the tadpoles—for some time after laying.

Distribution and conservation status



The Red-eyed Tree Frog (*Litoria chloris*)

The habitat of frogs extends almost worldwide, but they do not occur in Antarctica and are not present on many oceanic islands. The greatest diversity of frogs occurs in the tropical areas of the world, where water is readily available, suiting frogs' requirements due to their skin. Some frogs inhabit arid areas such as deserts, where water may not be easily accessible, and rely on specific adaptations to survive. The Australian genus *Cyclorana* and the American genus *Pternohyla* will bury themselves underground, create a water-impervious cocoon and hibernate during dry periods. Once it rains, they emerge, find a temporary pond and breed. Egg and tadpole development is very fast in comparison to most other frogs so that breeding is complete before the pond dries up. Some frog species are adapted to a cold environment; for instance the wood frog, whose habitat extends north of the Arctic Circle, buries itself in the ground during winter when much of its body freezes.

Frog populations have declined dramatically since the 1950s: more than one third of species are believed to be threatened with extinction and more than 120 species are suspected to be extinct since the 1980s.[43] Among these species are the golden toad of Costa Rica and the Gastric-brooding frogs of Australia. Habitat loss is a significant cause of frog population decline, as are pollutants, climate change, the introduction of non-indigenous predators/competitors, and emerging infectious diseases including. Many environmental scientists believe that amphibians, including frogs, are excellent biological indicators of broader ecosystem health because of their intermediate position in food webs, permeable skins, and typically biphasic life (aquatic larvae and terrestrial adults). It appears that it is the species with both aquatic eggs and aquatic larvae that are most affected by the decline, while those with direct development are the most resistant .

A Canadian study conducted in 2006, suggested heavy traffic near frog habitats as a large threat to frog populations. In a few cases, captive breeding programs have been attempted to alleviate the pressure on frog populations, and these have proved successful. In 2007, it was reported the application of certain probiotic bacteria could protect amphibians from disease. One current project, The Panama Amphibian Rescue and Conservation Project, has subsequently been developed in order to rescue species at risk of disease in eastern Panama, and to develop field applications of this probiotic cure.

Evolution Article *developmental cardiologist Benoit Bruneau.*

The first genetic link in the evolution of the heart from three-chambered to four-chambered has been found, illuminating part of the puzzle of how birds and mammals became warm-blooded.

Frogs have a three-chambered heart. It consists of two atria and one ventricle. As the right side of a frog's heart receives deoxygenated blood from the body, and the left side receives freshly oxygenated blood from the lungs, the two streams of blood mix together in the ventricle, sending out a concoction that is not fully oxygenated to the rest of the frog's body.

Turtles are a curious transition--they still have three chambers, but a wall, or septum is beginning to form in the single ventricle. This change affords the turtle's body blood that is slightly richer in oxygen than the frog's.

Birds and mammals, however, have a fully septated ventricle--a bona fide four-chambered heart. This configuration ensures the separation of low-pressure circulation to the lungs, and high-pressure pumping into the rest of the body.

As warm-blooded animals, we use a lot of energy and therefore need a great supply of oxygen for our activities. Thanks to our four-chambered heart, we are at an evolutionary advantage: we're able to roam, hunt and hide even in the cold of night, or the chill of winter.

But not all humans are so lucky to have an intact, four-chambered heart. At one or two percent, congenital heart disease is the most common birth defect. And a large portion of that is due to VSD, or ventricular septum defects. The condition is frequently correctable with surgery.

Benoit Bruneau of the Gladstone Institute of Cardiovascular Disease has honed into the molecular forces at work. In particular, he studies the transcription factor, Tbx5, in early stages of embryological development. He calls Tbx5 "a master regulator of the heart."

Scott Gilbert of Swarthmore College and Juli Wade of Michigan State University study evolutionary developmental biology of turtles and anole lizards respectively. When Bruneau teamed up with them, he was able to examine a wide evolutionary spectrum of animals. He found that in the cold-blooded, Tbx5 is expressed uniformly throughout the forming heart's wall. In contrast, warm-blooded embryos show the protein very clearly restricted to the left side of the ventricle. It is this restriction that allows for the separation between right and left ventricle.

Interestingly, in the turtle, a transitional animal anatomically--with a three-chambered, incompletely septated heart, the molecular signature is transitional as well. A higher concentration of Tbx5 is found on the left side of the heart, gradually dissipating towards the right.

Bruneau concludes: "The great thing about looking backwards like we've done with reptilian evolution is that it gives us a really good handle on how we can now look forward and try to understand how a protein like Tbx5 is involved in forming the heart and how in the case of congenital heart disease its function is impaired."

The journal *Nature* reports the finding in its Sept. 3 issue. The National Science Foundation supports the research. -NSF

What Do Frogs Eat and What Eats Frogs?

A frog catches a cricket in the jungle with his sticky tongue.

A lot of people have no idea that frogs are not only the prey of many larger animals, but also what frogs eat exactly. Have you ever had a pet frog? If not, that you are probably not familiar with the fact that frogs actually do eat other live prey and are definitely not vegetarians by any means. Insects, snails, spiders, worms and even small fish have all been known to be part of a frog's diet and while some bigger frogs had been known to go after something as big as a mouse, there are still those frogs that just stick to insects.

One of the neat facts about how frogs eat is that they have no teeth. Similar to snakes, frogs have to swallow their entire meal whole because they can not chew anything. Usually, frogs will only use the upper jaw to hold onto their prey, it is not used for biting or chewing at all. One of the most memorable things that people usually pick up on is the sticky tongue that all frogs have. This tongue takes less than a second to roll out and once it is out, whichever insect they are attempting to catch will not have any time at all to react.

Another cool fact about how frogs eat is the fact that their eyes help them swallow. As you may have noticed in some of the photographs of frogs up close, when frogs eat, their eyes actually sink through the opening of their skull in order force the food to go down their throat. This is one of the main reasons why it seems as if frogs are constantly blinking while they are eating.

When it comes down to it, frogs are pretty low on the food chain. Now, they do have a few defense mechanisms, such as their color being able to change and the fact that they are so fast in their jumping ability, but in general, there are many different animals that make frog part of their diet.

Snakes, foxes, dogs, bass, pike, hawks and even seagulls have all been known to fest on frogs on a regular basis, but there are many humans that have made frogs part of their diet. In France, frog legs are definitely one of the top menu items in some of the best French restaurants. While you may think that most of the water frogs may be safe from creatures attempting to make a meal out of them, water frogs are usually a regular diet for many of the sharp-toothed fish and even sharks in the world.

This blue heron bird has caught a frog.

If you are out hunting for a frog to make it part of your dinner, be sure that you are watching out for the poisonous frogs. While poisonous frogs do not make their home in every single state, you still need to be careful and read up on the colors of frogs. Many red, blue, purple and even bright green frogs can be extremely poisonous to us humans.

82
FROG: IV DISSECTION

This plate orients you to anticipated dissection of the internal viscera of the frog *(Rana catesbeiana).* Three levels of dissection are shown: upper left is a superficial view after opening the ventral body wall and seeing undisturbed structures; upper right shows an intermediate level of structure as seen when the lobes of the liver are lifted out of the way; and the two lower illustrations expose the deepest level of structure as it appears in the female (left) and male. There is considerable variety in the disposition of structures among individual frogs. The amount of *fat bodies* in frogs varies seasonally. In the female specimens dissected, the number of eggs in the *ovaries* were much reduced compared to those seen in female frogs during breeding season.

Color the structures in each drawing, starting at upper left and moving to upper right and then to lower left and to lower right. Color each drawing completely before going on to the next. Be sure to set aside the coloring markers used in the first illustration so that you may use them again in subsequent illustrations. The unlabeled tissue or region surrounding the structures to be colored represents peritoneum or fibromuscular tissue, which is difficult to precisely identify.

To open the body (pleuroperitoneal) cavity, lay the preserved frog on its back and make a shallow incision through the ventral body wall to one side or the other of the midline. Make your incision from the tip of the chin to the posterior extremity of the ventral body wall. Be careful when you open the body cavity so as to avoid cutting visceral structures. If you use scissors, be extremely careful, as the hidden underlying blade can often cut through structure. If you use a scalpel, be *exceedingly* careful to avoid cutting deeper structure or yourself. After making a longitudinal incision, make two transverse incisions above and below to create skin flaps. Pull the flaps to the sides and pin them to your dissection tray and the viscera will lie before you. If your frog has been injected with a dye to show the circulatory vessels, an amount of dye may have leaked onto the upper surface of the liver. Scrape it off gently before continuing.

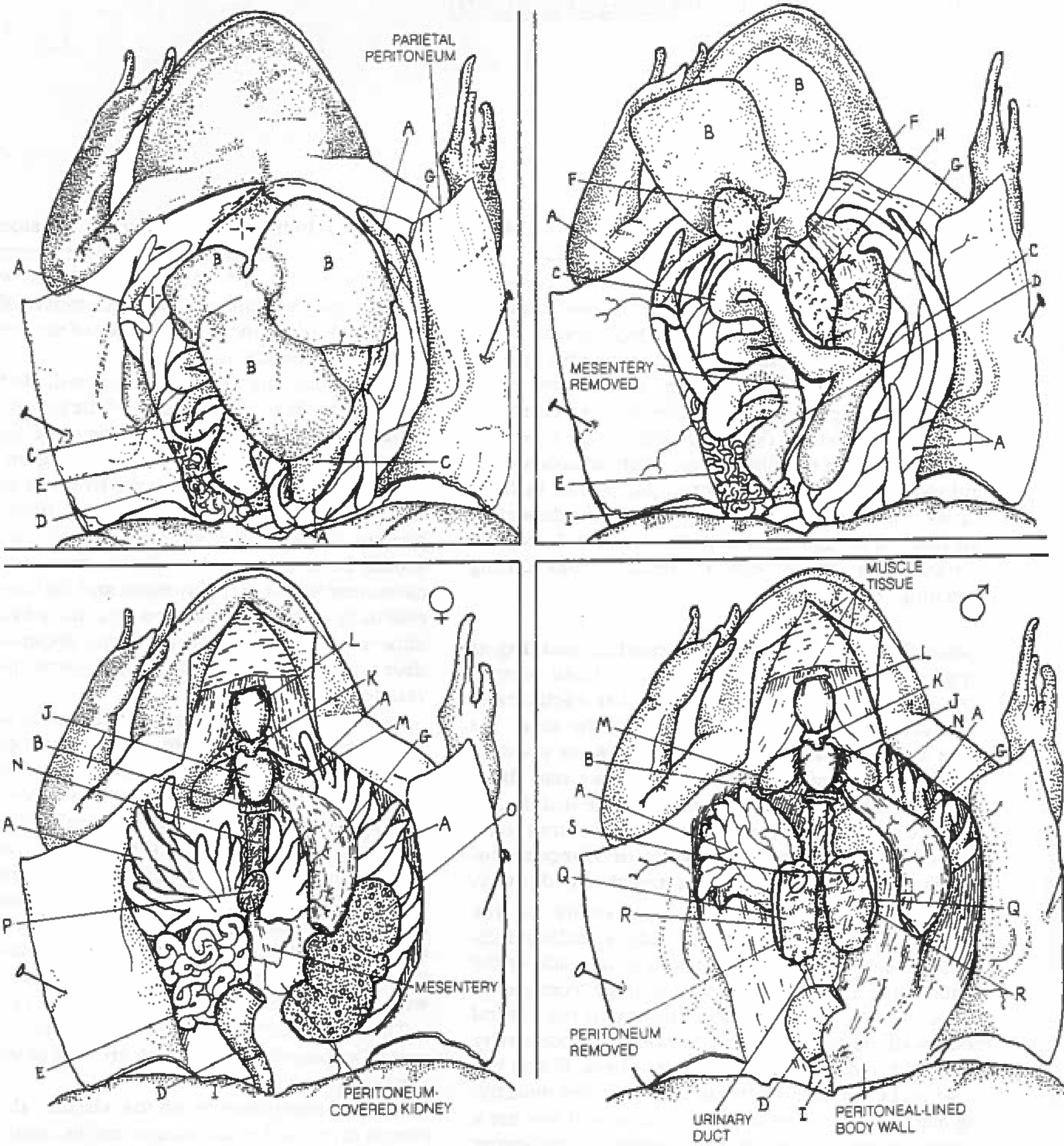
In first opening the cavity, you will find that the lobes of the *liver* take up much of the interior. Fingers of *fat bodies* and possibly big masses of eggs within the *ovary* may also fill the cavity. Lifting the *liver* upward and toward the chin of the frog will expose the digestive viscera and *oviducts.* The *intestines* suspended by peritoneal mesenteries and the *stomach* should be clearly in view. In the transparent, filmy mesentery between the *stomach* and the loop of *intestine* to its immediate left, you will find a yellow glandular structure *(pancreas).* On the underside of the *liver* you will see a rounded, clear (sometimes green) vesicle *(gall bladder).*

Removing the *liver* from its connections just below the *heart,* and the *intestines* and their mesenteries, will expose the structures lying against the dorsal body wall. The *heart, conus/truncus arteriosus,* and left and right *lungs* can be easily visualized. Blunt dissection above the *heart* will reveal the trachea and *larynx.* In the abdominal region, the reddish *spleen* can be seen in the midline in a mass of peritoneum. Removal of this organ and the parietal peritoneum on the dorsal body wall will reveal the *postcaval vein* in the midline and the dark brown *kidneys* (laterally), on whose lateral surface the *adrenal glands* can be seen.

The *testes* can be seen at the upper part of the *kidneys.* The *ovaries* and *oviducts* are easy to visualize in the female specimen.

Further identification of the viscera, their parts, connections, and relationships, can be made in coloring the next five plates on frog systems.

FROG: IV DISSECTION.

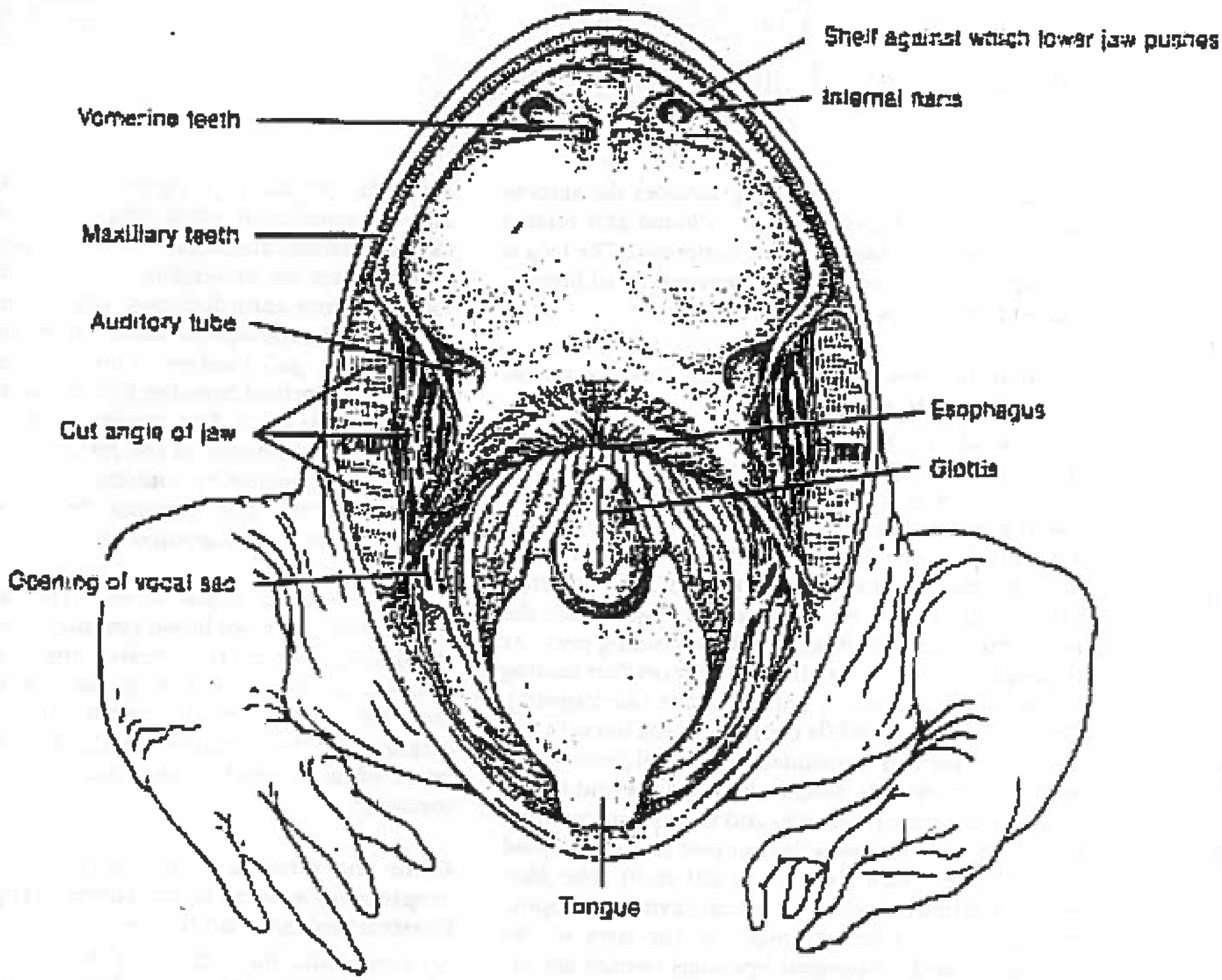


FAT BODY A
LIVER B
SMALL INTESTINE C
LARGE INTESTINE D
OVIDUCT E
GALL BLADDER F
STOMACH G
PANCREAS H

RECTUM I

HEART J
CONUS/TRUNCUS ARTERIOSUS K
LARYNX L
LUNGS M
POSTCAVAL VEIN N

OVARY O
SPLEEN P
KIDNEY Q
ADRENAL GL. R
TESTES S



Interior view of the buccopharyngeal cavity of a male frog. The angles of the jaw have been cut so that the mouth can be opened widely.

85

FROG: VII DIGESTIVE AND RESPIRATORY SYSTEMS

The digestive system of the frog includes the alimentary canal from buccal cavity to *cloaca* and related glands *(liver, gall bladder,* and *pancreas).* The frog is primarily carnivorous (worms, spiders, small insects, and so forth). It swallows its food whole.

Color structures A through R and related titles. Then read below.

The buccal cavity (mouth, oral cavity) is bounded laterally by the upper and lower jaws. The margin of the upper jaw bears small *maxillary teeth;* the lower jaw has none. The roof of the cavity is the palate, which is perforated anteriorly by a pair of *internal nostrils* conducting air into the mouth from the external nostrils. Medial to the *internal nostrils* are the *vomerine teeth,* which are used for holding prey. At the angle of the jaws are the *auditory orifices* leading to the middle-ear cavity (lateral to the otic capsule). The muscular *tongue* fills the floor of the buccal cavity and is lined with keratinized epithelial tissue laden with taste buds. The *tongue* is projectile and sticky (from intermaxillary glands) and is used for catching prey. Its muscular root arises in part from the hyoid bone (derived from the second gill arch). The *pharynx* is continuous with the buccal cavity (buccopharyngeal cavity) from the angle of the jaws to the respiratory and esophageal openings (which are arranged ventrally and dorsally, respectively).

The short, muscular *esophagus* conducts food through the anterior body cavity (dorsal to the *larynx*) to the *stomach.* The *stomach,* suspended by peritoneal ligaments (dorsal and ventral mesenteries), is a large, saclike receptacle for storing food. Some digestion of protein occurs here. Posteriorly, the *stomach* narrows to become the *small intestine,* which immediately turns upward (anteriorly). Lying within the loop thus formed is the rather diffuse, lobular, yellow *pancreas,* as well as the *common bile duct* from the *gall bladder, liver,* and *pancreas.* Extensive enzymatic and mechanical digestion occurs in the *small intestine,* which coils tightly after the first straight part. The *small intestine* merges into the dilated, shorter *large intestine* (colon) in the lower right quadrant of the peritoneal-lined body cavity. The *large intestine,* responsible mainly for absorbing water and packaging fecal material, opens into the *cloaca* (a chamber shared with urinary and genital ducts).

The three-lobed *liver* is the largest gland in the body. It receives all absorbed nutrients from the *intestine* via the hepatic portal vein. It alters and stores metabolic products of digestion and releases them into the circulation when needed for utilization by the body tissues and organs. The *liver* produces bile, which makes fat dispersible in water and therefore subject to enzymatic digestion. Bile is transported out of the *liver* by the *hepatic ducts.* These, and the *cystic ducts* of the *gall bladder* (which concentrates and stores bile received from the *hepatic ducts*), form the *common bile duct.* The *common bile duct* passes through the substance of the *pancreas,* receives its *duct,* and terminates by entering the first part of the *small intestine.* The enzymes from the *pancreas* assist in chemical digestion of fats, protein, and sugars.

The *spleen* (an organ of the lymphatic system) breaks down aged red blood corpuscles brought in by the splenic arteries. The released pigment material is absorbed by the veins of the *spleen* and conducted to the *liver* (via the hepatic portal vein), where it is employed in the formation of bile. The *spleen* is also involved in the production of red blood cells (erythropoiesis).

Color the structures and related titles of the respiratory system in the lower left part of the illustration and read below.

Air passes into the oral cavity through the *nostrils,* which then close. The floor of the mouth rises (contraction of submaxillary muscle), forcing air into the slitlike *glottis* on the laryngeal swelling located between the *tongue* and the *esophagus.* The *glottis* opens into the *larynx,* a chamber supported by cartilage (derived from gill arches) and containing two muscular vocal cords oriented dorsoventrally. Sound is created by movement of air passing between vibrating vocal cords, as well as by rapid expulsion of air from paired vocal sacs (not shown) opening into the *pharynx* of males. Air passes through the *larynx* into two tubular, cartilaginous *bronchi* (sing. bronchus; *brawn*-kus), partly because of relaxation of the muscles of the abdominal wall. One *bronchus* passes into each *lung* and breaks up into progressively smaller ducts. These ducts ultimately open into sacs of air cells (alveoli) surrounded by capillaries. It is between these alveoli (sing. alveolus; al-*vee*-oh-lus) and the blood capillaries that exchange of oxygen and carbon dioxide occurs. Air is returned to the outside by recoiling of elastic fibers in the *lungs* and contraction of the abdominal muscles, which puts pressure on the *lungs.*

FROG: VII

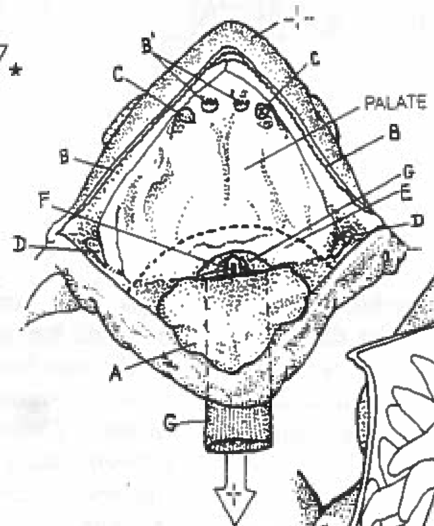
DIGESTIVE SYSTEM.

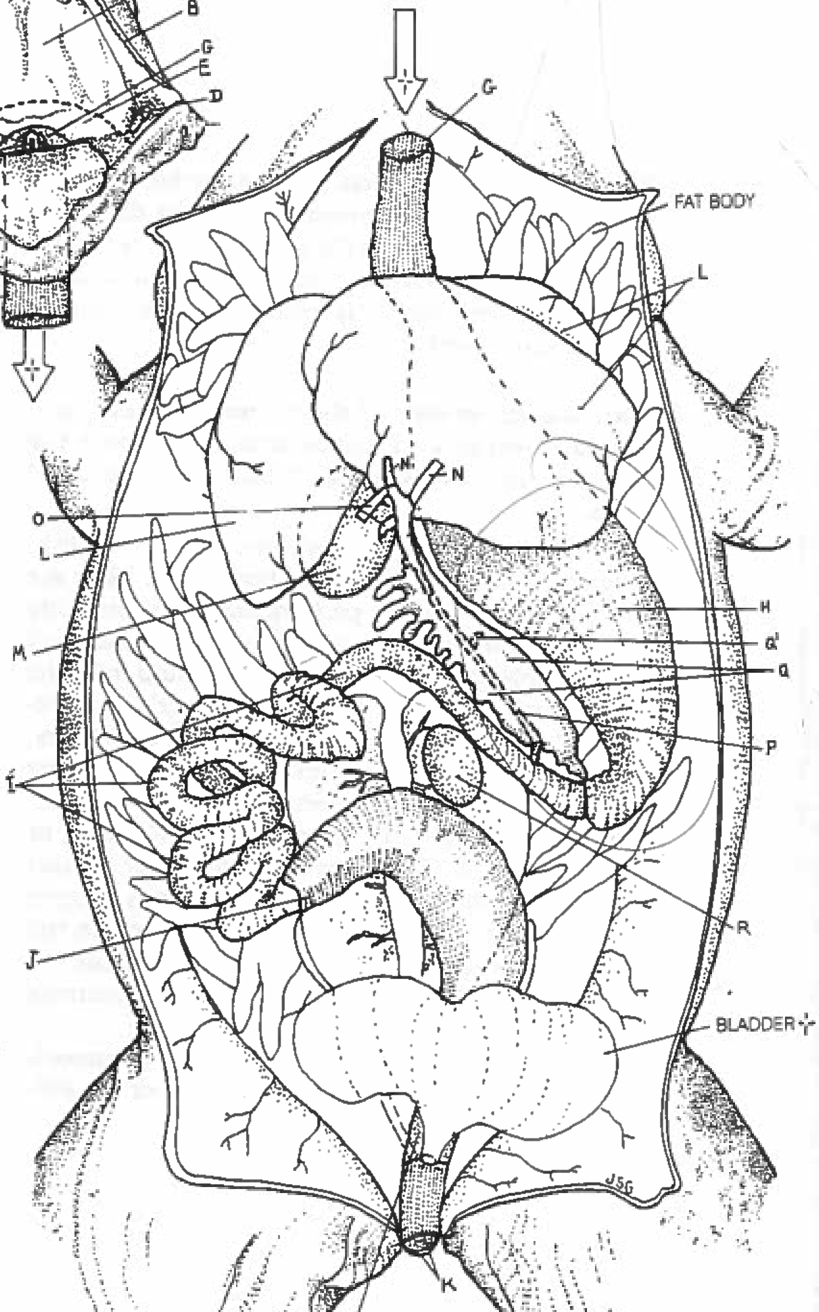
BUCCAL CAVITY*
- TONGUE A
- MAXILLARY TEETH B
- VOMERINE TEETH B'
- INTERNAL NOSTRIL C
- AUDITORY ORIFICE D

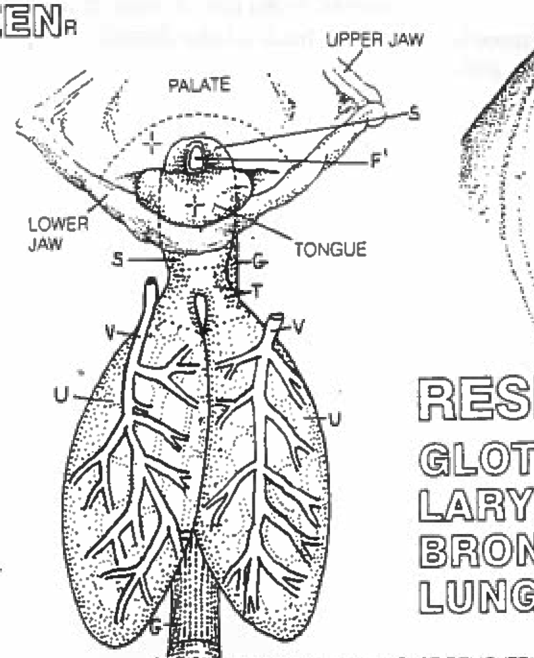
PHARYNX E
- GLOTTIS F

ESOPHAGUS G
STOMACH H
SMALL INTESTINE I
LARGE INTESTINE J
CLOACA K
LIVER L
GALL BLADDER M
HEPATIC DUCT N
CYSTIC DUCT O
COMMON BILE DUCT P
PANCREAS Q
- PANCREATIC DUCT Q'

SPLEEN R







VENTRAL VIEW (HEART REMOVED)

RESPIRATORY SYSTEM.

GLOTTIS F'
LARYNX S
BRONCHUS T
LUNG U
PULMONARY VESSELS V

86
FROG: VIII UROGENITAL SYSTEM

The gonads *(testes* and *ovaries)* and the *kidneys* arise embryologically as neighboring masses on the dorsal wall of the body cavity. In the male frog, the *testes* and the *kidney* tubules share a common (urogenital) *duct*. In the female, the *oviduct* is separate from the urinary *(archinephric) duct*.

Color the structures of the urinary system (and related titles) in both sexes first, then color the male reproductive system. While coloring, read below.

The *kidneys* (mesonephros) are dark, reddish, elongated bodies on the dorsal body wall. They are covered over by parietal peritoneum lining the body cavity. Each *kidney* consists, in part, of thousands of tubules (nephrons). These tubules filter fluid from the blood of small branches of the renal arteries and exchange fluid and various molecules with capillaries, which wrap around the tubules. These tubules deliver their filtrate (urine) into collecting ducts that open into the larger *archinephric* (mesonephric, Wolffian, or urogenital) *duct*. The *archinephric duct* passes posteriorly on the lateral aspect of the *kidney* to open into the *cloaca*. The *bladder*, located ventral to the *ducts*, stores urine arriving at the *cloaca* from the paired *archinephric ducts* and releases its contents back into the *cloaca* for discharge.

The paired *testes* are rounded bodies lying immediately ventral to the upper (anterior) poles of the *kidneys*. They (and the ovaries in the female) are the site of origin for the fat bodies, which may be quite extensively distributed in the body cavity. Each *testis* consists of numerous sperm-producing (seminiferous) tubules. These tubules coalesce to form a number of *efferent ducts* conducting sperm cells to the *kidney* tubules. Sperm and filtrate from the blood pass through the *kidney* tubules into the *archinephric duct* and are conveyed to the *cloaca*. At their posterior extremities, the *ducts* expand to form *seminal vesicles*, which discharge stored sperm during copulation.

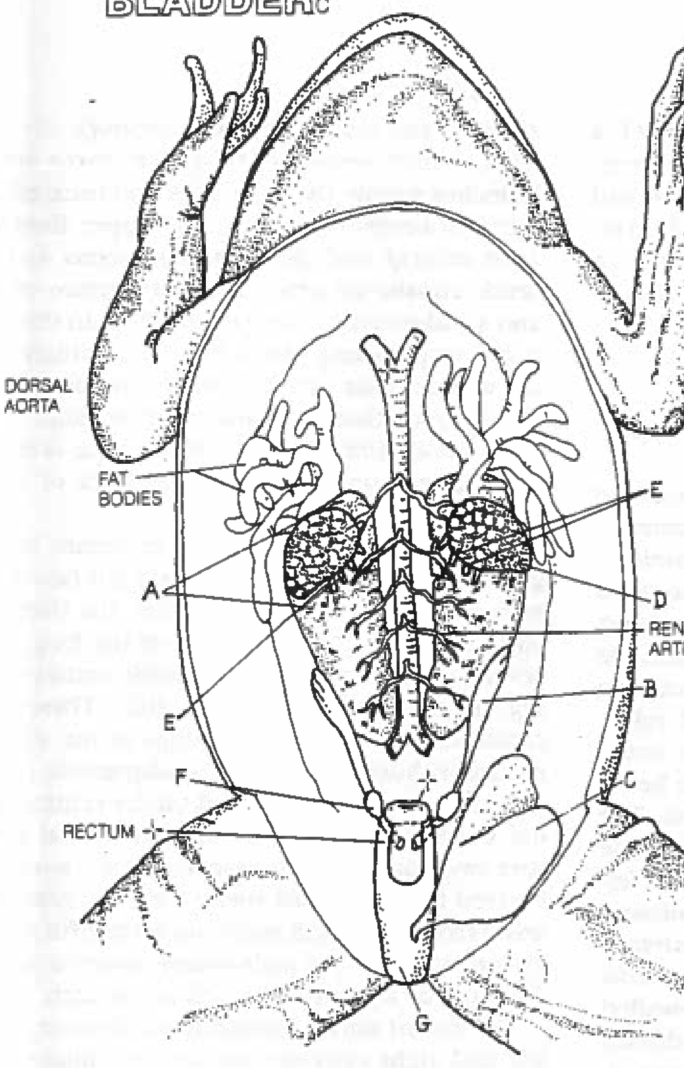
Color the structures of the female reproductive system and related titles. Then read below.

The *ovaries* are paired, highly lobulated, often massive organs (when filled with *eggs*) ventral to the *kidneys*. During breeding season, *egg*-filled *ovar*[ies] may fill the entire body cavity. These immature *e*[ggs] are ultimately discharged into the body cavity and, with the aid of peritoneal cilia, migrate anteriorly to the ciliated openings (tubal ostia) of the paired *oviducts*. The *eggs* pass through the highly convoluted *oviduct* into the dilated *uterus* (ovisac), where they are stored. During copulation, the *eggs* are discharged from the *uterus* to the *cloaca*, then to the outside, where they are fertilized by the sperm ejected from the *cloaca* of the male, who is mounted on the back of the female.

FROG: VIII UROGENITAL SYSTEM.

URINARY SYSTEM.*

KIDNEY A
ARCHINEPHRIC DUCT B
BLADDER C

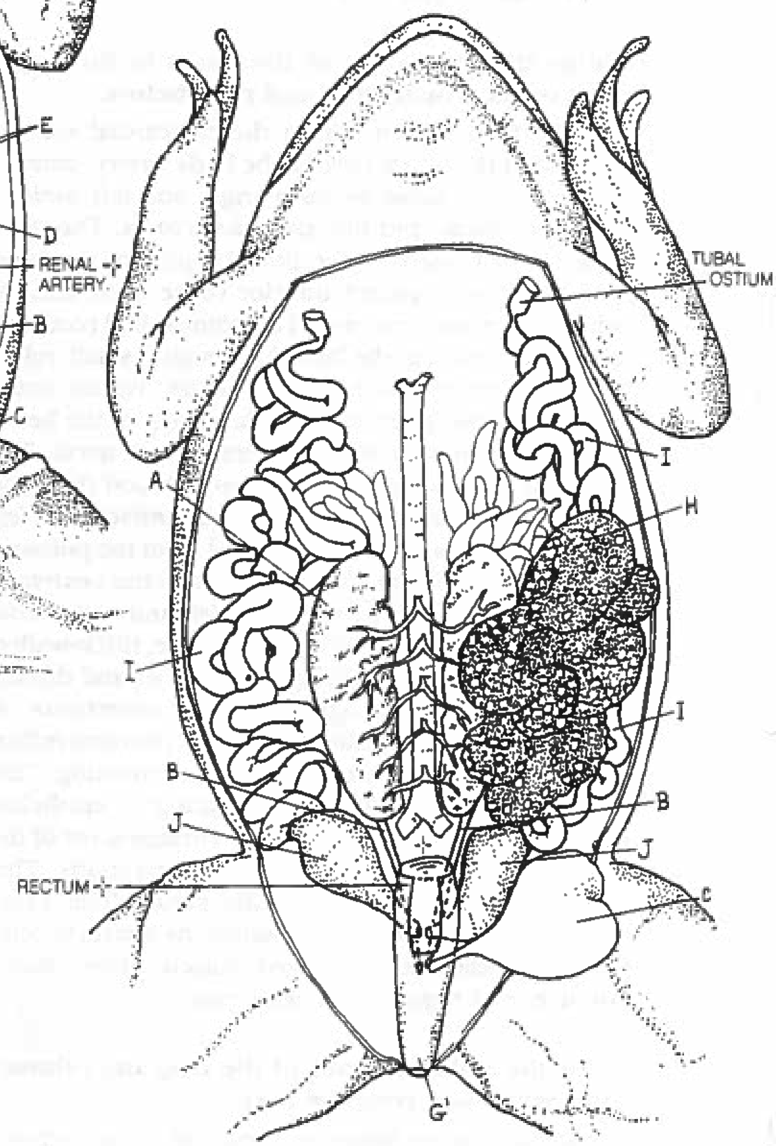


MALE REPRODUCTIVE SYSTEM.*

TESTIS D
EFFERENT DUCTS E
ARCHINEPHRIC DUCT B
SEMINAL VESICLE F
CLOACA G

FEMALE REPRODUCTIVE SYSTEM.*

OVARY/EGGS H
OVIDUCT I
UTERUS J
CLOACA G'



83
FROG: V HEART AND ARTERIAL SYSTEM

The circulatory system of the frog consists of a muscular pump (the heart) and a network of vessels (in direction of blood flow: arteries, capillaries, and veins). The arrangement of these vessels is fairly typical for terrestrial vertebrates but differs from the aquatic vertebrates because of the shift from gills to lungs and cutaneous respiration, and the vascular requirements of four limbs.

Color the structures of the heart in the upper part of the illustration and read below.

The heart, enclosed within the pericardial sac and located in the upper part of the body cavity, consists of four parts: *sinus venosus,* right and left *atria,* a single *ventricle,* and the *conus arteriosus.* The *sinus venosus* is located on the dorsal aspect of the heart and receives the paired anterior venae cavae and the single posterior vena cava. This thin-walled receiving chamber conducts the blood through a small valve-guarded orifice into the *right atrium.* Valves, structured from the inner (endothelial) lining of the heart, resist a backflow of blood. There are two *atria.* The *right atrium* receives deoxygenated blood from the *sinus venosus* and conducts it to the *ventricle;* the *left atrium* receives oxygenated blood from the pulmonary veins of the lung and delivers it to the *ventricle.* The septum or wall between the *left* and *right atria* may or may not be complete. The single, thick-walled *ventricle* is the major pump of the heart and directs blood anteriorly through the *conus arteriosus.* A valve at the proximal end of the *conus* prevents reflux of blood when the *ventricle* is not contracting. The heart wall consists of an inner lining of epithelial tissue (endothelium) and a thick, working layer of interlacing cardiac muscle fibers (myocardium). The outer layer is a thin peritoneumlike pericardium. Contractions of the heart are maintained by a cardiac conduction system of specialized muscle fibers; autonomic nerves regulate the heart rate.

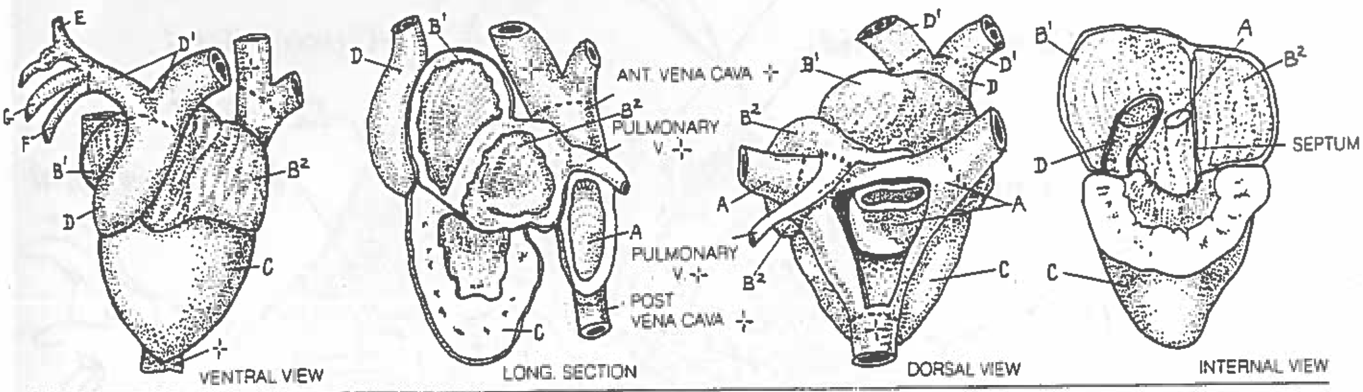
Color the major arteries of the frog and related titles while you read the text.

The major arteries springing from the *conus arteriosus* are the left and right arterial trunks *(truncus arteriosus).* From each trunk spring three arches: the anterior *carotid arch,* whose carotid arteries supply the buccal cavity and pharynx (external carotid, not shown) and brain (*internal carotid);* the *systemic arch,* which becomes the *dorsal aorta* and whose branches supply the deep neck and back of the head *(occipitovertebral artery)* and upper limb *(subclavian artery);* and the *pulmocutaneous arch,* which sends *cutaneous arteries* to the surface of the skin and a *pulmonary artery* to the lung. In the frog (and other amphibians), the skin is exceedingly thin and the animal must live in a moist environment to prevent dehydration. A considerable exchange of oxygen and carbon dioxide occurs through the skin between the ambient air and the fine network of cutaneous vessels.

The arrangement of the above arches is homologous with three of the five or six gill (aortic) arches seen in the shark and bony fishes: the third, fourth, and sixth. In the tadpole stage of the frog, there several pairs (three to six) of aortic arches surrounding the ill-fated (temporary) gills. These gills are replaced functionally with lungs in the adult. After metamorphosis, the following adaptations take place: The *conus arteriosus* located on the ventral aspect of the heart is derived from the old ventral aorta; the first two aortic arches disappear; the *carotid arch* is derived from the third aortic arch; the *systemic arch* arises from the fourth aortic arch; the fifth aortic arch disappears; and the *pulmonary arteries* arise from the sixth or a part of the sixth aortic arch.

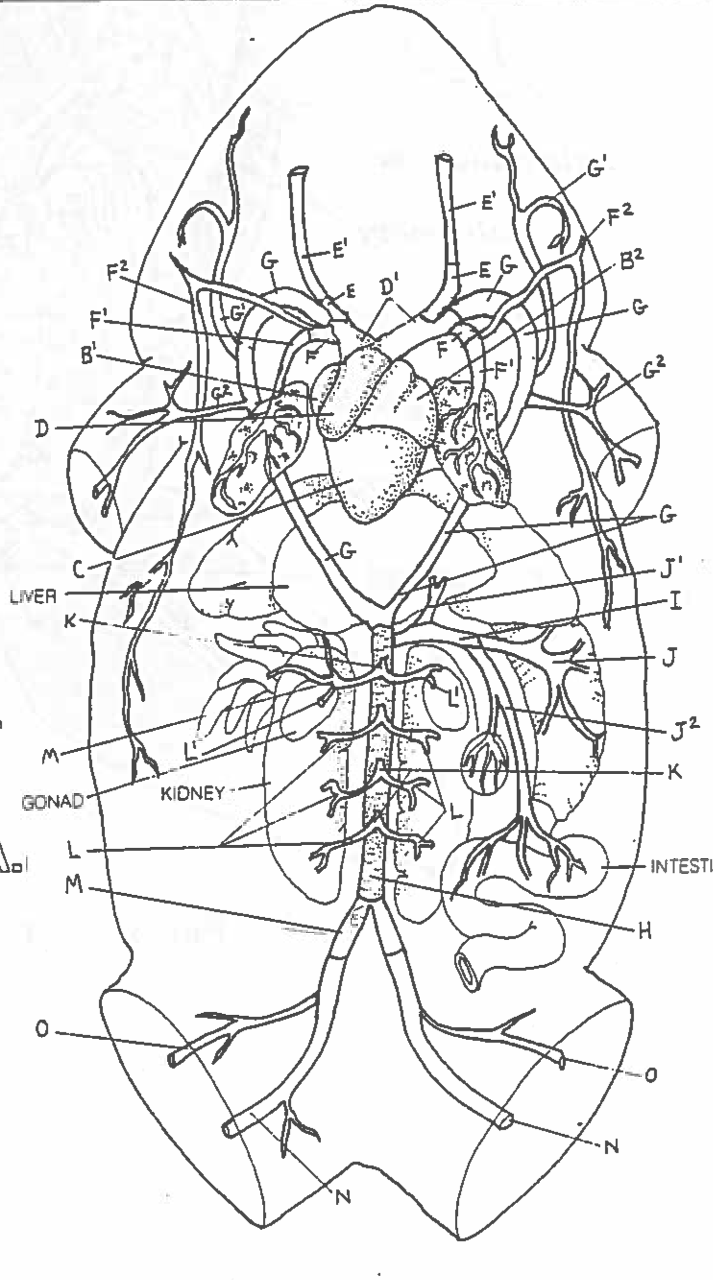
The *dorsal aorta,* formed from the merging of the left and right *systemic arches,* lies adjacent to the posterior vena cava against the vertebral bodies and sends off its first major branch (unpaired) to the digestive tract *(coeliacomesenteric artery).* Unpaired branches of this artery supply the stomach *(coeliac artery),* the liver *(hepatic artery),* and the intestines *(mesenteric artery).* Posterior to the *coeliacomesenteric artery,* the *dorsal aorta* gives off three to six single, ventral, midline *urogenital arteries,* which immediately divide into left and right vessels. The gonads, immediately adjacent to the kidneys, receive *genital* branches, and the kidneys receive *renal* branches from these urogenital vessels. At the level of the upper pelvic girdle, the *dorsal aorta* bifurcates to left and right *common iliac arteries.* The major branches of these arteries are the smaller *femoral arteries* and the larger, more dorsal *sciatic arteries,* both of which supply the lower limb.

FROG: V HEART AND ARTERIAL SYSTEM.



HEART*
SINUS VENOSUS A
ATRIUM: RIGHT B¹/LEFT B²
VENTRICLE C
CONUS ARTERIOSUS D

ARTERIES*
TRUNCUS ARTERIOSUS D'
CAROTID ARCH E
  INT. CAROTID A. E'
PULMOCUTANEOUS ARCH F
  PULMONARY A. F'
  CUTANEOUS A. F²
SYSTEMIC ARCH G
  OCCIPITOVERTEBRAL A. G'
  SUBCLAVIAN A. G²
DORSAL AORTA H
  COELIACOMESENTERIC A. I
    COELIAC A. J
    HEPATIC A. J'
    MESENTERIC A. J²
  UROGENITAL A. K
    RENAL A. L
    GENITAL A. L'
COMMON ILIAC A. M
    SCIATIC A. N
    FEMORAL A. O



VENTRAL VIEW

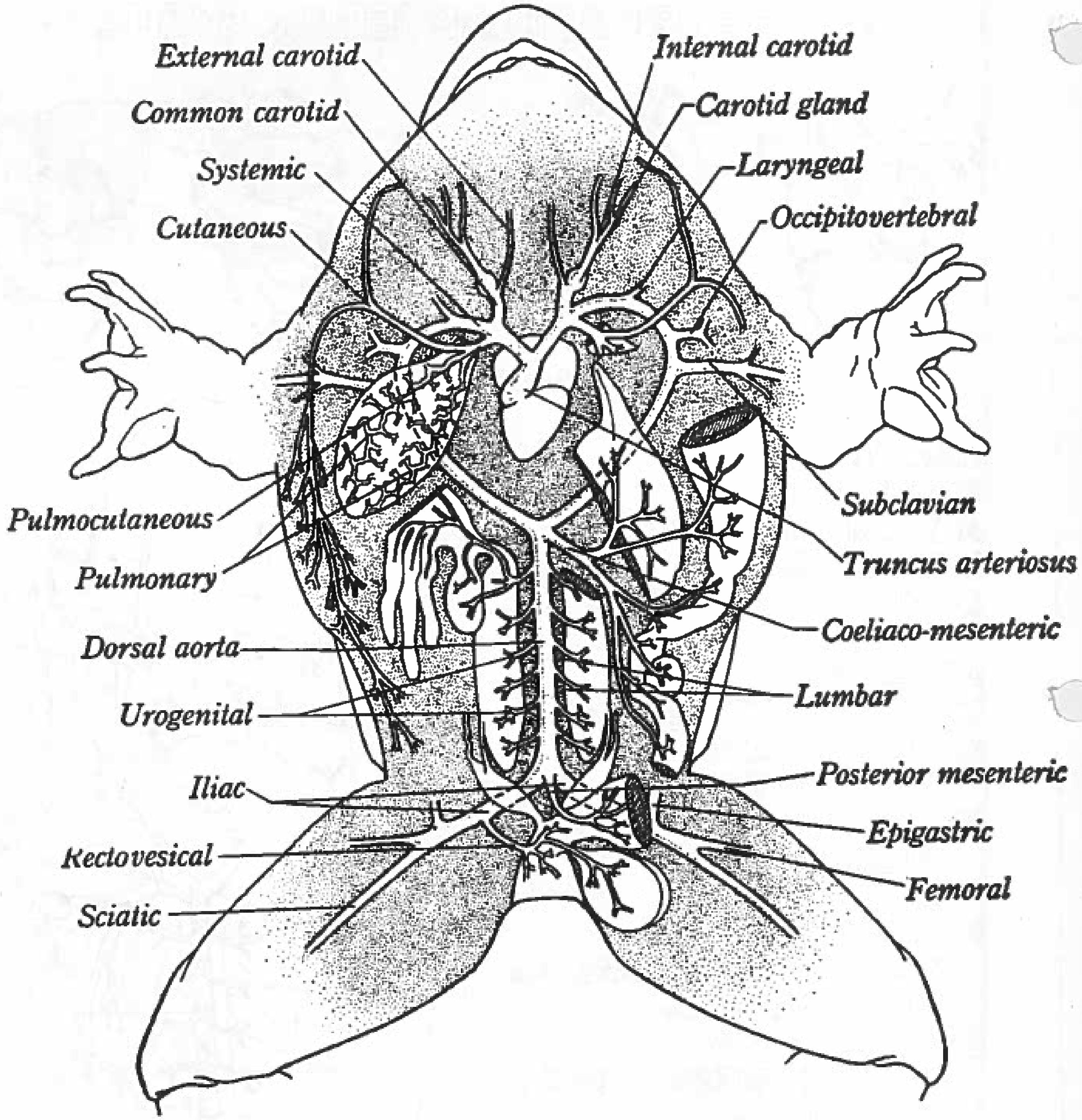


FIG. 394. *Arterial System of Frog*

79
FROG: I SKELETON

The bony skeleton, the cartilaginous parts, and fibrous connective tissue make up the supporting elements of the frog body. The body consists of the following regions: the *head,* the *trunk,* and the *forelimbs* and *hindlimbs.*

Color structures A through K and read below.

The skull of the frog consists of both bony and cartilaginous parts, whose joints are supported and strengthened by ligaments. The *upper jaw* consists of three bones on each side: the tooth-bearing premaxilla and maxilla and the quadratojugal bones. The posterior extremity of the quadratojugal bone is attached to the squamosal bone by ligaments. Meckel's cartilage of the lower jaw (not shown) articulates with a cartilaginous process of the squamosal bone (lower jaw joint).

The nasal region is supported by both cartilage and bone. The major bones supporting the nasal capsule (containing olfactory sensory structures) are the nasal bones *(roof of the nasal cavity)* and the premaxillae. The nasal region opens anteriorly at the nostrils and posteriorly into the pharynx just behind the oral cavity.

The brain is surrounded by both cartilaginous and bony elements (cranial region) of the skull. The major bones are the frontoparietals *(roof)* and the exoccipitals. The frontoparietal bone is bordered laterally by the orbital cavities (for the eyes) and the prootic (pro-*oh*-tik) bones. The exoccipital bone articulates with the *atlas* and forms a circular, ringlike opening (foramen magnum) for the spinal cord. Inner ear organs (concerned with sound reception and sensitivity to head position) fill the *otic capsule* (auditory region), which is largely protected by prootic, exoccipital, and squamosal bones.

The *palate* (roof of the oral cavity and floor of the orbit) is quite large and is supported by cartilage and the pterygoid (*tare*-ee-goyd), palatine, and sphenethmoid bones (the latter directly deep or internal to the anterior frontoparietal bone).

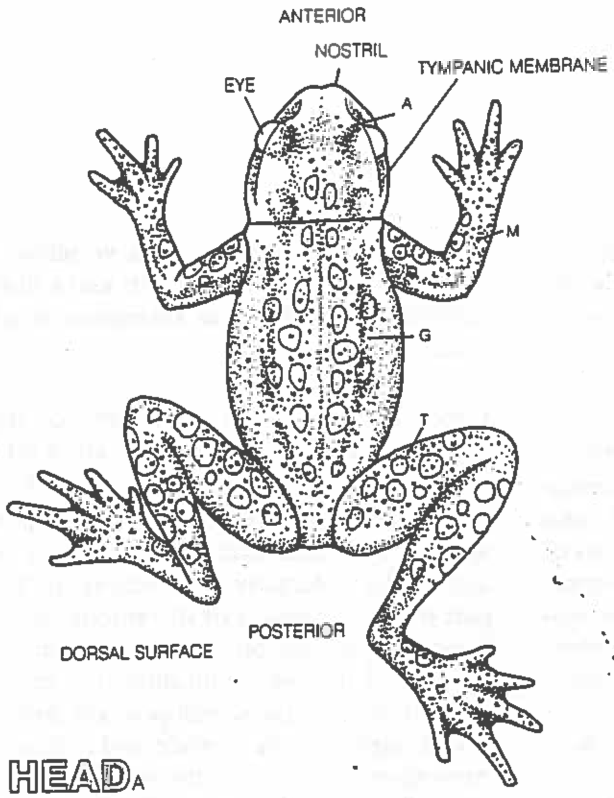
The vertebral column, which is the principal supporting structure of the *trunk* specifically and the entire body in general, consists of an *atlas,* seven trunk or *dorsal vertebrae,* a *sacral vertebra* with large transverse processes, and the *urostyle,* which represents the tail vertebrae. Each vertebra consists of a ventral body (supporting part) and a dorsal arch (for muscle attachment and transmission of the spinal cord).

Color the titles and structures of the forelimb and hindlimb and their respective girdles. Color the encircled structures below and read below.

The *pectoral girdle* on each side is shaped like a U on its side, open end facing the midline of the back, one arm of the U dorsally, one arm ventrally. The lower part of the U consists of the anterior clavicle and the posterior procoracoid attached to the breastbone or sternum in the ventral midline. The base (bottom) of the U is the scapula, which projects dorsally from the lateral border of the clavicle and procoracoid. In the view shown, only the edge of the scapula projecting upward or dorsally is seen. The flat suprascapula, attached to the upper part of the scapula, is the dorsal arm of the U. The *humerus* is joined to the procoracoid and scapula at the glenoid fossa (shoulder joint) and to the fused *radioulna* at the elbow. The stout *radioulna* moves on two of the several cartilaginous *carpal* elements at the wrist joint. The *metacarpals* support the palm of the hand, and the *phalanges* (sing. phalanx) are the bones of the fingers. The first *metacarpal bone* (much smaller than the others) is a vestigial thumb and has no phalanges.

The bones of the *hindlimb* are supported by the *pelvic girdle,* consisting of three paired bones (the ilium, the ischium, and the pubis). The two ilia articulate anteriorly with the ninth *(sacral) vertebra;* posteriorly, they fuse with the ischial and pubic bones. The *femur* articulates with the *girdle* in a cup-shaped socket (acetabulum; ass-eh-*tab*-yoo-lum) formed by the three fused bones. The *femur* articulates at the knee with the *tibiofibula,* which joins distally with the long, paired *tarsal bones.* These *tarsal bones* (and smaller ones, not shown) form the major support for the large foot so important in locomotion. The *tarsal bones* articulate with the five *metatarsal bones,* which join to the bases of the five proximal *phalanges.* Note the spurlike prehallux as well as the number of *phalanges* in each of the five digits of the *hindlimb.*

FROG: I SKELETON.

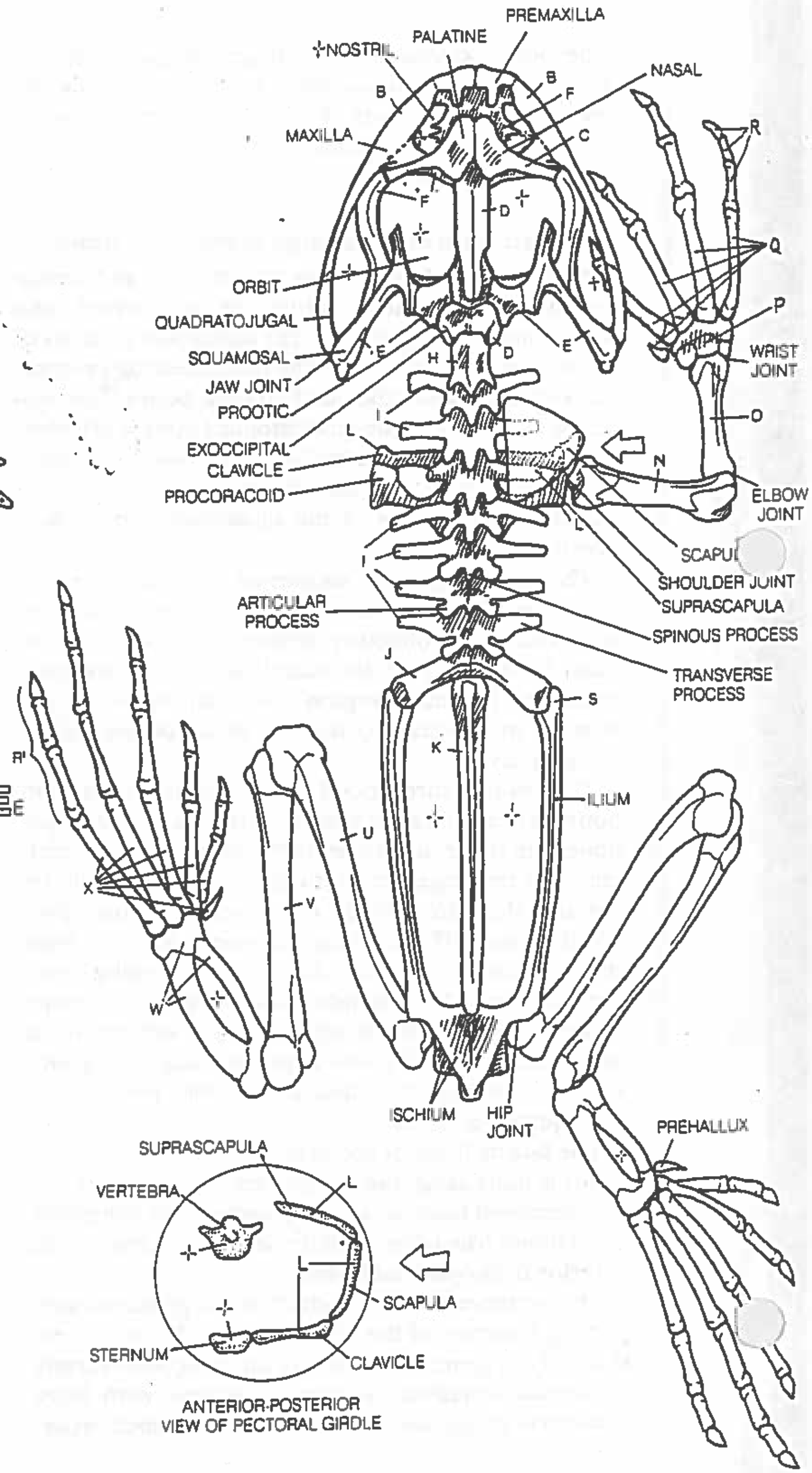


HEAD A
SKULL ★
UPPER JAW B
ROOF OF NASAL REGION C
ROOF OF BRAINCASE D
ROOF OF OTIC CAPSULE E
BONES OF PALATE F

TRUNK G
VERTEBRAL COLUMN ★
ATLAS H
DORSAL VERTEBRA I
SACRAL VERTEBRA J
UROSTYLE K

PECTORAL GIRDLE L
FORELIMB M
HUMERUS N
RADIOULNA O
CARPAL BONES P
METACARPAL BONES Q
PHALANGES R

PELVIC GIRDLE S
HINDLIMB T
FEMUR U
TIBIOFIBULA V
TARSAL BONES W
METATARSAL BONES X
PHALANGES R'



ANTERIOR-POSTERIOR VIEW OF PECTORAL GIRDLE

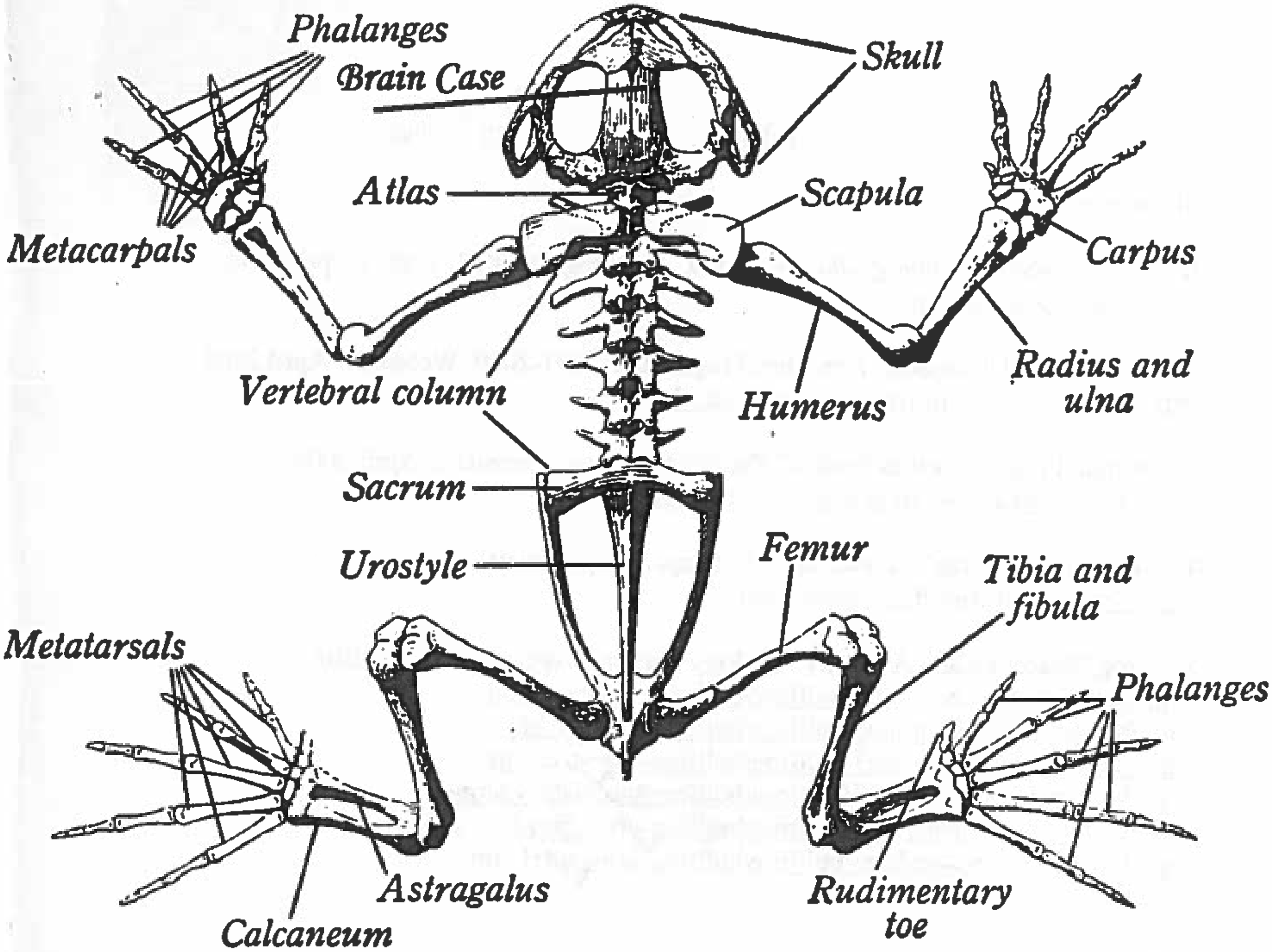


FIG. 400. *Skeleton of Frog*. Modified, after Jammes

87
FROG: IX NERVOUS SYSTEM

The organization of the frog brain is similar to the shark brain colored in Plate 74. An overview of vertebrate brain structure and function can be colored in Plate 107. This plate stresses cranial and spinal nerve organization and function.

Color the structures of the brain and spinal cord and related titles A through G. Then read below.

The *olfactory lobe* and *cerebrum* are a part of the forebrain (telencephalon) and are concerned with receipt of impulses from the olfactory nerves and conducting related impulses to lower centers of the brain. The *cerebrum* is not well developed in the amphibian brain. The diencephalon (posterior part of the forebrain) is arranged into a dorsal *pineal gland,* a ventral hypothalamus, and the *thalamus* in between. The *thalamus* is concerned with integrating sensory input and distributing related impulses to other parts of the brain. The hypothalamus regulates the autonomic (visceral) nervous system as well as much of the endocrine system, among other functions. There is no clear understanding of the function of the *pineal gland* in the frog. The *optic lobes* (of the midbrain or mesencephalon) are the principal centers for generating motor responses to all sensory input and have connections with motor components of cranial and spinal nerves. The *cerebellum* (part of the metencephalon) functions in maintaining equilibrium and postural stability. It receives input from the inner-ear vestibular apparatus and from position receptors (proprioceptors) in tendons and joints and then influences motor impulses from the midbrain to achieve body movement appropriate to the occasion. The *medulla oblongata* (posterior hindbrain or myelencephalon) is continuous with the *spinal cord* through the foramen magnum of the skull. Within this region are centers for such reflexes as heart rate, control of blood flow, and respiration.

The *spinal cord* consists of an H-shaped central column of nerve cells and peripheral bundles of nerve fibers. The *spinal cord* is not capable of the complex integrative and response capacity of the brain; it is basically an extension of the brain for handling limb reflexes, receiving and channeling sensory input to the brain, and conducting motor impulses from the brain to motor nerves.

Color the cranial and spinal nerves and related titles. Then read below.

Ten pairs of nerves arise from the brain; these are the cranial nerves of the peripheral nervous system. The *olfactory nerve,* sensitive to smell, has its receptors located in the nostrils. The *optic nerve* conducts visual impulses from the eye (retina) to the *optic lobe.* The *third, fourth,* and *sixth* cranial *nerves* (oculomotor, trochlear, and abducens) supply impulses to the muscles that move the eye. The fifth cranial or *trigeminal nerve* receives sensory input from the skin of the head and supplies motor nerves to the muscles that close the mouth. The seventh cranial or *facial nerve* is sensory from the mouth and tongue (taste) and sends motor nerves to muscles below the floor of the mouth. The eighth cranial or *auditory nerve* conducts sensory information from the internal ear (hearing and head equilibrium) to the brain. The ninth cranial or *glossopharyngeal nerve* receives taste impulses from the pharynx and supplies small muscles there. The tenth cranial or *vagus nerve* supplies the laryngeal muscles and sends secretomotor fibers (parasympathetic fibers of the autonomic nervous system; see Plate 107) to viscera in the body cavity.

Ten pairs of spinal nerves arise from the spinal cord, pass out between the vertebral arches, and disperse to various regions of the body. The first spinal nerve corresponds to the *hypoglossal* or twelfth cranial nerve of mammals and innervates the muscles of the tongue. The second and third spinal nerves contribute to the formation of the *brachial plexus,* whose terminal nerves supply the muscles and skin of the forelimb. *Spinal nerves four through six* supply the muscles of the body wall and overlying skin. Spinal nerves seven through ten contribute to the *sciatic plexus,* whose terminal nerves, including the *sciatic* (sye-*at*-ik) *nerve,* supply the muscles and skin of the hindlimb.

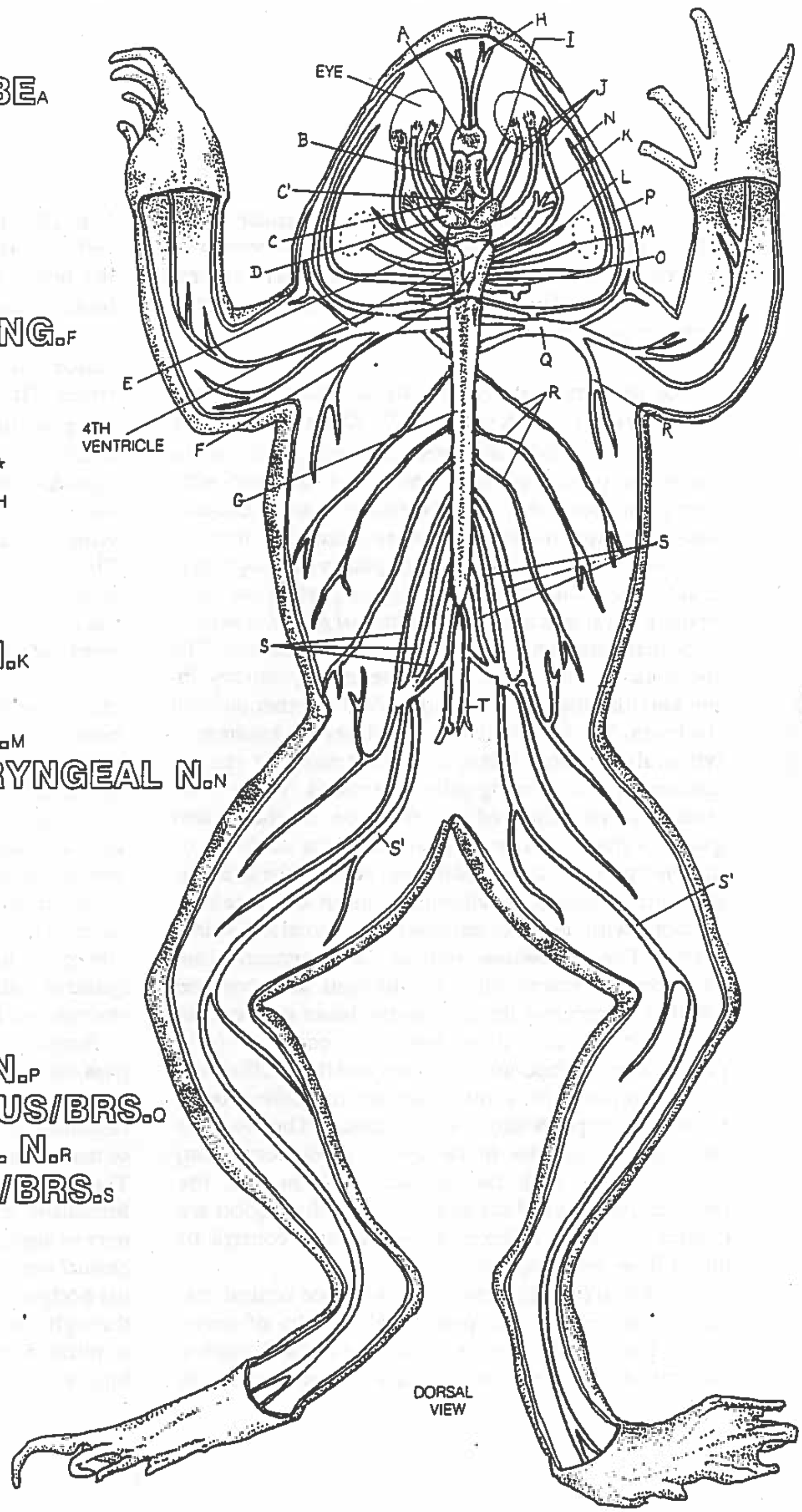
FROG: IX NERVOUS SYSTEM.

BRAIN*
- OLFACTORY LOBE A
- CEREBRUM B
- THALAMUS C
- PINEAL GL. C'
- OPTIC LOBE D
- CEREBELLUM E
- MEDULLA OBLONG. F

SPINAL CORD G

CRANIAL NERVES*
- I OLFACTORY N. H
- II OPTIC N. I
- III, IV, VI Ns. TO EYE J
- V TRIGEMINAL N. K
- VII FACIAL N. L
- VIII AUDITORY N. M
- IX GLOSSOPHARYNGEAL N. N
- X VAGUS N. O

SPINAL NERVES*
- HYPOGLOSSAL N. P
- BRACHIAL PLEXUS/BRS. Q
- 4TH–6TH SPINAL N. R
- SCIATIC PLEXUS/BRS. S
  - SCIATIC N. S'
- 10TH SPINAL N. T



Bibliography: (From Green Folders)

Electronic Sources

1. "Frog Dissection" *Biology Junction.coml.* Massengale, 2008. Web. 5 April 2008.
http://www.biologyjunction.com/

2. "Virtual Frog Dissection" *Frogguts*, Froguts Inc, 2001-2009. Website. 5 April 2008.
http://www.froguts.com/flash_content/index.html

3. " Virtual Frog Dissection Project" *The Science Guys*, Website. 5 April 2008.
http://www.ofsd.k12.wi.us/science/frogdiss.htm

4. " Anatomy of a Frog" *Amphibian,* Webpage. 5 April 2010.
http://www.lookd.com/frogs/index.html

5. " Frog Dissection and Anatomy" Biology Corner, Webpage. 5 April 2010.
http://biologycorner.com/bio3/bullfrog/bullfrog-external.html
http://biologycorner.com/bio3/bullfrog/bullfrog-internal.htm
http://biologycorner.com/bio3/bullfrog/bullfrog-digestive.html
http://biologycorner.com/bio3/bullfrog/bullfrog-circulatory.html
http://biologycorner.com/bio3/bullfrog/bullfrog-artery.html
http://biologycorner.com/bio3/bullfrog/bullfrog-urogenital.htm

Books

1. Biggs, A., et al. *Biology: The Dynamics of Life*. 1st ed. Westerville, OH: Glencoe/McGraw Hill, 1995. Print.

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